CIAT's Contribution to the Detection and Control of Invasive Pests in the Greater Caribbean Region.

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This presentation is based on the paper written by Dr A. Bellotti and myself on invasive pests, presented three years ago in the T-STAR Workshop. Copies of this paper are available for anyone interested. I will try to offer some points of view on why we witness an increasing number of invasive and emergent pests that threaten our food security every year. The second part of the paper contains updated information on some of the invasive pests we have encountered or researched in Colombia.

Some Recent History

To better understand the constant emergence of new invasive pests and the significant damage they cause in various agricultural regions of the world, we should review some recent economic developments in the world, particularly the globalization of the economy and its impact on the global trade of agricultural commodities.

The first two factors I want to highlight are the liberalization of trade, and the existence of surpluses of several agricultural commodities subsidized in various industrialized nations. These two factors have greatly increased the volume of agricultural commodities exchanges and the speed at which they are traded, as most of the quarantine barriers previously in place have been removed. Thus, tons of seed of various food staples and industrial crops arrive in developing countries, depriving local farmers of markets for their traditional crops, such as maize and beans, in the case of Latin America. We should recall that the same farmers domesticated these crops. For example, Colombia used to be self-sufficient in maize; and last year, it imported two million tons. Ships loaded with cheap rice produced in Asia roam the oceans in search of ports to unload. Most of these massive grain shipments have not gone through proper pest control and quarantine procedures.

Moreover, affected farmers and governments have had to develop a competitive agriculture through crop diversification. In Latin America, the emphasis has been on horticultural and fruit crops, due to their intensive labor demand available in developing countries. This drive for competitiveness in a world with a more liberalized trade has resulted in an intensive exchange of seed and vegetative materials. In addition international trade in ornamentals and cut flowers have facilitated the spread of leafminers, aphids and thrips species. These shipments of planting materials and export of traditional and non-traditional agricultural products have increased the movement of invasive pests in the Americas and other agricultural regions of the world. The international movement of pests is further facilitated by the current WTO regulations, which replaced the old quarantine procedures with new time-consuming and costly pest risk analyses for every group of commodities. Not all national systems can comply with these rules, resulting in introductions of plant material, which would not have occurred previously. The rapid rise of tourism to developing countries undoubtedly contributed to the increased pest distribution.

The third factor I want to highlight is the following. The impact of the globalization of the economy was magnified by the recession of the western world in the 1980s, and the so-called structural adjustments, which were later implemented by the IMF. This involved a drastic reduction in government spending and employment. Agricultural research and extension were particularly affected. National research organizations in Latin America have been reduced to a fraction of their previous strength and attempts were made, with little success, to privatize research. Few extension services have survived but there is very little indigenously generated technology to be transferred. For example, when I left CIAT in 1986, Guatemala had 11 bean research scientists; when I returned ten years later, only one bean researcher remained. The pressure to address environmental issues related to agriculture in developing countries has further aggravated this disastrous trend.

Thus, there is no or little research done in developing countries on new crops and their pests, some of which have been introduced or have emerged as cropping systems change. These pests are not managed by well-supported research and extension systems, which were debilitated by the structural adjustment programs. The only extension service still available to farmers is the pesticide sales force, and this has resulted in the current horrific abuse of pesticides. With beneficial insects tending to be more susceptible to pesticides than the pests, this problem is further aggravated. Moreover, donor wisdom that research must be financed through finite three-year projects does not provide for the flexible deployment of resources needed to develop a concerted research strategy to combat incipient or newly established invasive pests and pathogens.

CIAT's Response.

The above developments are of considerable concern to CIAT. The Center traditionally focused its research on beans, rice, forages and cassava. With beans and rice now out-competed by subsidized imports, CIAT's original mandate became less relevant. Yet, the Center had to respond to the constant emergence of new invasive pests, such as the B biotype of the whitefly *Bemisia tabaci*, *Thrips palmi*, the pink hibiscus mealybug (*Maconellicoccus hirsutus*), rice stripe necrosis, and many other pests and pathogens. These new pests also occurred on the crops presently researched at CIAT. Examples include the introduction of the cassava mealybug and the cassava green mite into Africa. Combined research by CIAT, IITA and EMBRAPA resulted in the identification of their natural enemies in the centers of origin of these pests. Subsequently these natural enemies were introduced into Africa. These parasitoids and predators rapidly established themselves, and saved African farmers from famine.

Another example is the development of moderate levels of resistance in beans to the recently arrived *Thrips palmi*.
But this research capacity was not available in CIAT to support research in non-mandated crops, such as tomatoes, cucurbits, broccoli, etc.

CIAT, in an effort to improve its relevance, reorganized its research drastically around competency areas centered on the improvement of cropping systems or watersheds. The five research competency areas are: Integrated Pest and Disease Management, soil fertility management, land use (with GIS), biodiversity (plant breeding, genetic resources and biotechnology tools) and socio-economics. Each of these five competencies remained active in the traditional crops, but they are increasingly responding to the needs of major pest problems in other crops. In this way research could now focus also on tomato, African oil palm, asparagus, fruit crops, etc. Currently, CIAT's research activities cover ornamental, fruit and horticultural, and industrial crops. In addition, CIAT undertook research in the management of natural resources.

Another parallel development occurred. CIAT realized, that given the magnitude of the research task (more crops and natural resources), and the small size of the institute, it could only make an impact by doing cooperative research together with others. Therefore CIAT organized a science park, called Agronatura. This is not an assembly of individuals that merely share the same infrastructure and fence. Instead, all members of the science park, in order to gain entrance, must have the same goal and mission as CIAT: i.e. how to make the small farmer competitive and to make agriculture less damaging to the environment. Thus the total of the 23 institutions, including the private sector that share the park at this moment all work in one general theme. This results in much synergism and increased relevant impact. It is CIAT's sincere wish that the University of Florida, with its tropical research program, particularly on tropical fruits and pest management, will one day be an important member of this science park.

This new structure and broader vision permitted the rapid formation and dismemberment of new research associations. The geographic position, culture, infrastructure, experience in networking, and scientific expertise to monitor and carry out innovative research, enabled CIAT to assume a significant role in the study and management of invasive pests in a wide range of cropping systems. When the whitefly problem became severe, CIAT with other centers, both national and international coordinated the creation of the Tropical Whitefly Project, probably one of the most ambitious global pest management projects, currently covering Latin America, Sub-Saharan Africa and South-East Asia. This project has contributed to the identification of the main viruses transmitted by whiteflies, as well as to the characterization of the main whitefly species and biotypes of *Bemisia tabaci* the main pest and plant virus vector worldwide.

An update on invasive pests.

In the remainder of the article I would like to expand briefly on recent information generated in CIAT, often through collaborative projects, on invasive pests and conclude with a summary of research on natural enemies of whiteflies.

A). Invasive viruses, particularly the highly threatening whitefly transmitted viruses.
Rice. Rice hoja blanca is the main viral disease of rice in tropical America, and has attacked rice in the United States (Louisiana and Florida) in the past. CIAT characterized the causal virus in the 1980s and has since developed an efficient rice improvement program to control this disease. If there is a warming trend in the Caribbean, this disease may reemerge in the southern USA.

Rice stripe necrosis is the only other virus disease of rice known to occur in the Americas. The causal virus and its fungus vector where probably introduced in contaminated rice seed imported into Latin America from West Africa in the early 1990s. The fungus vector was originally described on cereal crops in temperate countries, and it has now moved up from South America through Central America, probably all the way to Nicaragua. This virus has the potential to move into North America, considering its seed-borne nature and the adaptation of the fungus vector, *Polymyxa graminis*, to temperate environments. CIAT has developed diagnostic materials and disease management practices that have greatly reduced the economic and environmental impact of this exotic disease.

In June 2003, we received notice of a new whitefly transmitted virus outbreak in El Salvador. Symptoms coincide with preliminary reports from Cuba and the Dominican Republic. The virus causes leaves to turn orange, followed by necrosis. We are monitoring this potential, new pest with great concern, as it reports on whitefly damage to grass species.

Common bean. In Latin America, common beans are grown in both temperate and tropical countries. This diversity of environments facilitates the recombination and dissemination of plant pathogens in different regions. For instance, a highly pathogenic new virus was detected in Chile attacking common beans. The causal virus was later shown to be a natural recombinant virus from a cross between *Cucumber mosaic virus* and *Peanut stunt virus*. The seed-borne recombinant virus is a threat to common bean production worldwide.

Bean severe mosaic is caused by some comoviruses transmitted by chrysomelids in Central America. These viruses cause systemic necrosis in bean genotypes possessing I gene resistance to bean common mosaic, a common gene found in most North American bean cultivars. Whitefly-borne *Bean calico mosaic virus* attacks legumes and cucurbits in northwestern Mexico, and could easily travel east to affect the snap bean industry in Florida.

Tropical and subtropical forage grasses and legumes are susceptible to different viruses found in temperate and tropical regions of the world. Peanut stripe was originally introduced in the U.S. from Asia, and later transported into Latin America. Although the virus was successfully eradicated from S.E. United States, its emergence in northern South America might lead to its re-introduction in the U.S. In tropical forage grasses, such as *Brachiaria* spp., exotic viruses, probable of African origin, have been detected in Latin America.

Cassava. Frogskin disease in the Americas (causal agent and vector are unknown), and African cassava mosaic in Africa and some Asian countries are major threats to cassava production worldwide.

African oil palm. Colombia is the largest producer of African oil palm in the Americas, and, consequently, is concerned about the slow but continuous spread of exotic viral diseases probably introduced to the Americas from West Africa. The CIAT Virology Unit identified these elusive pathogens in 1999, and succeeded in the isolation of two different viruses. The new viruses are: African oil palm ringspot virus (vector unknown) and African oil palm chlorotic ring virus (aphid-borne). These are the first viruses ever identified in this globally important oil crop.

Tropical fruits. Unidentified exotic viruses have been detected at CIAT in most tropical fruit crops assayed to date. These tropical fruit crops include: tree tomato (tomate de arbol), naranjillo (lulo), feijoa, passion fruit (maracuja), pitahaya cactus, and banana. Some of these viruses can be disseminated directly from fruits sold in foreign markets through insect vectors.

Vegetables. Some 20 uncharacterized new viruses have been detected in the past six years in tomato, sweet and hot peppers and cucurbits. Interesting research is being carried out in El Salvador with farmers using nylon mesh tunnels to exclude the vector as one component of an IPM package.

B). Invasive insects. The importance of invasive insects as vectors of virus diseases is particularly severe.

Whiteflies. CIAT's research activities with invasive insect pests include several whitefly species, including *Bemisia afer* sensu lato, a species native to Africa. It was first reported on sweet potato in the Canete Valley in coastal Peru and has been seen on cassava as well. By the year 2000 it was reported in damaging populations, although it may have been present in the Americas much earlier.
It'-s role as a virus vector of Solanaceous crops is being investigated, particularly as related to the *Solanum muricatum* export to Europe. *Aleurocanthus woglumi* (the citrus blackfly or spiny citrus whitefly) is another threatening whitefly species.
Other important species include the *Bemisia tabaci* complex.

Rice. The rice mite (*Steneotarsonemus spinki*) and the rice thrips (*Stenchaetotrips biformis*), are threatening to several grass species.

Others. *Thrips palmi* arrived in the Caribbean about 1990, and resistance to this exceedingly damaging pest has been identified in beans.

Other important indigenous arthropod pests with somewhat restricted distribution that could potentially spread to other areas, or crops, include the tropical fruit flies (*Anastrepha grandis* and *A. suspensa*), the apple maggot (*Rhagoletis pomonella*), the pink hibiscus mealybug *(Maconellicoccus hirsutus*), the Guatemalan potato moth (*Tecia solanivora*), and the citrus leafminer (*Phyllocnistis citrella).*

Whiteflies and their Natural Enemies

Surveys in recent years in the Neotropics - especially in Colombia, Venezuela, Ecuador and Brazil, have identified a large complex of natural enemies associated with the whitefly complexes found on cassava, vegetable legumes, and other crops. This complex of natural enemies includes parasitoids, predators and entomopathogens. Agro-ecological zones have been defined for two whitefly species, *Bemisia tabaci* and *Trialeurodes vaporariorum* feeding on numerous crops in Colombia and Ecuador. Three genera of whitefly parasitoids, *Amitus, Encarsia,* and *Eretmocerus* were collected from *B. tabaci* and *T. vaporariorum* feeding on these crops. Surveys in Colombia and Ecuador confirm the following five whitefly species feeding on cassava, *Aleurotrachelus socialis, Bemisia tuberculata, Trialeurodes variabilis, Tetraleurodes* sp. and *Aleurodicus* sp. Surveys on cassava in Colombia have resulted in the identification of at least 10 parasitoid species associated with the whitefly species; four from Ecuador and seven from Venezuela. Several of the parasitoid are unrecorded species and they have been submitted to taxonomists in USA universities for identification

Whitefly species and their natural enemies have also been collected in the aforementioned countries from eggplant, tomato, cabbage, cucumber, snap bean, cotton, bell pepper, soybean, lima bean, watermelon, peanut, melon and field beans. Two whitefly species were identified from these hosts, *Bemisia tabaci* and *Trialeurodes* *vaporariorum*. *T. vaporariorum* was the species most often collected in Colombia while *B. tabaci* predominated in Ecuador. *B. tabaci* was most often collected from sites below 400 m.a.s.l., and *T. vaporariorum* from sites above 1000 m.a.s.l. At altitudes between 400-800 m.a.s.l., the two biotypes of *B. tabaci* as well as *T. vaporariorum* can be found.

The parasites collected from these surveys from whiteflies feeding on the above mentioned hosts belong to the genera *Encarsia, Eretmocerus* and *Amitus*. Several of the parasitoids collected have now been identified to species: including *Amitus fuscipennis, Encarsia sofia, Encarsia hispida, Encarsia nigricephala* and *Encarsia tabacivora*. Numerous other species, especially of the genera *Eretmocerus* and *Amitus* are still awaiting identification by US taxonomists; several of these are unrecorded species.

This species complex of natural enemies associated with whiteflies in the neotropics on cassava and other hosts need to be further evaluated and investigated to determine their role and importance in biological control programs.

Clearly, the mounting threat of invasive species calls for greaty expanded research to safeguard the Greater Caribbean Region. CIAT is seeking serious and effective partners in this critically important task.

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CABI, Crop Protection Compendium.